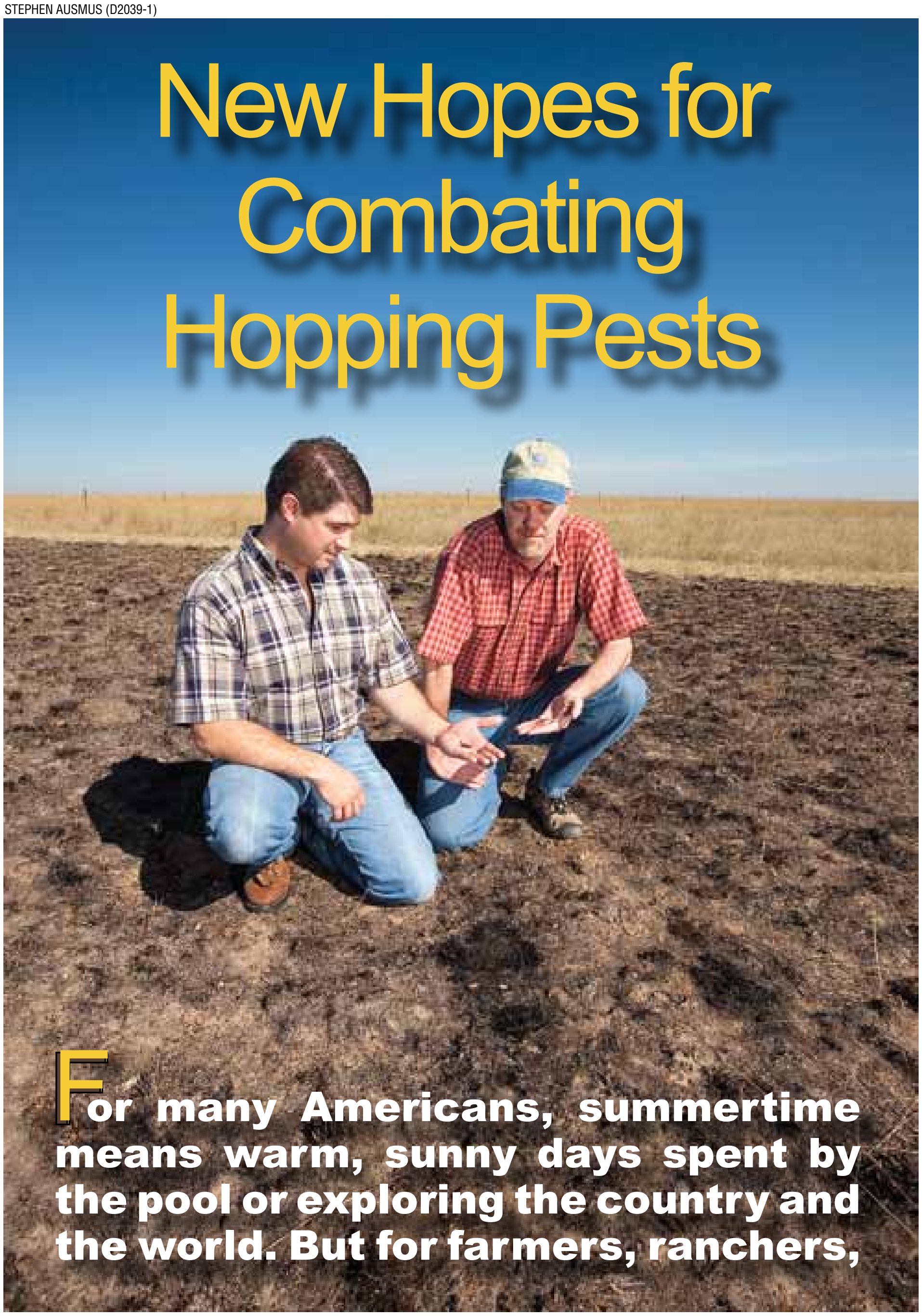
STEPHEN AUSMUS (D2039-1)

New Hopes for Combating Hopping Pests



Ecologist Lance Vermeire (left) and entomologist Dave Branson inspect a burn site in Terry, Montana, to determine how grasshopper populations are affected by late summer or early fall fires.

For many Americans, summertime means warm, sunny days spent by the pool or exploring the country and the world. But for farmers, ranchers, scientists, and state pest control organizations in the western half of the country, summer also means a chance of infestations of hopping pests, particularly grasshoppers and Mormon crickets.

Each adult female grasshopper can lay multiple egg pods—each containing many eggs—in one summer, which could greatly increase the population the next summer, after the eggs hatch. This compounding effect could lead to drastic yield losses for farmers and ranchers as grasshoppers, who can eat their body weight daily in vegetation, leave less grass on the rangeland for livestock and sometimes move into crops and feed on wheat and alfalfa.

State and federal pest control agencies spend millions of dollars each year to control grasshopper and cricket populations. During a particularly bad infestation, the cost can skyrocket. Coupled with the loss of revenue for farmers and ranchers, a grasshopper infestation could cost our country billions of dollars per year.

That's why a team of scientists in the Pest Management Research Unit at the ARS Northern Plains Agricultural Research Laboratory, Sidney, Montana—working with state, federal, and university collaborators—is researching ways to better manage grasshopper outbreaks.

Population Management Is Key

Entomologist David Branson is playing with fire. But it's not a bad thing. "We're researching how controlled burns of rangeland areas can be used to manage grasshopper populations, either through changing food availability or mortality of grasshoppers and unhatched eggs," he says.

Branson is working with ecologist Lance Vermeire, with the ARS Fort Keogh Livestock and Range Research Laboratory in Miles City, Montana, and ecologist Gregory Sword, a former ARS researcher who is now with Texas A&M University.

The researchers have conducted several studies examining how grasshopper populations are affected by late summer and early fall fires, which occur after the insects lay some or all of their eggs. It has been commonly assumed that insects living or hibernating in the soil would be protected from grassland fires.

In one laboratory study, Branson and Vermeire sought to determine whether increased soil temperature from fire affects grasshopper eggs laid at different depths. They compared egg mortality rates of two common pest species of North American grasshoppers—*Ageneotettix deorum,* which lays shallow egg pods, and *Melanoplus sanguinipes,* which lays deeper, more vertically oriented egg pods.

The scientists used a propane heater to simulate the increase in soil temperature during rangeland fire. They found that 80 percent of the shallow-laid eggs of *A. deorum* were killed. On the other hand, none of *M. sanguinipes*' deeper-laid eggs were killed.

"The study shows that fire can be used to selectively manipulate the population dynamics of a common pest grasshopper species," says Branson. "But we can't rely on controlled burns alone to manage grasshopper populations. It's just one tool in the arsenal."

Branson and colleagues are also examining the effect livestock grazing could have on grasshopper populations. Since grasshoppers have to compete with livestock for food, grazing could be used to prevent or moderate damaging grasshopper outbreaks.

Branson and Sword recently completed a study of grasshopper community responses to fire and livestock grazing. "In contrast to chemical control, these types of habitat manipulations have the potential to keep grasshopper populations below economically threatening levels," says Branson.

The 5-year study, which took place in the northern Great Plains mixed-grass prairie, examined the effects of livestock grazing and fire on grasshopper population density and community composition. The scientists studied the effects of three different livestock grazing systems—twice-over rotational grazing, season-long grazing, and ungrazed control—in burned and unburned habitats.

Despite overall low grasshopper densities during the study, Branson and Sword found that grasshopper diversity was significantly higher with twice-over rotational grazing. They also found both fire and grazing significantly affected grasshopper populations and community composition. For example, grasshopper densities were higher in burned pastures with season-long grazing.

More long-term studies during periods with greater grasshopper densities are needed to better assess the effects of grazing or fire on grasshopper population dynamics.

Crickets Create Chaos, Too

The grasshopper isn't the only insect wreaking havoc in the Northern Plains states. Its cousin, the Mormon cricket, is also plaguing farmers and ranchers. The two insects are closely related and belong to the insect order Orthoptera.

STEPHEN AUSMUS (D2043-3)

One goal of ARS scientists is to successfully rear Mormon crickets in the laboratory to better understand immune system development as the insect grows. Shown left to right are four of the insect's life stages: egg, first instar nymph, third instar nymph, and adult female.

BETH REDLIN (D2047-1)

Prior to testing a fungus's effect on Mormon cricket populations, ARS entomologist Stefan Jaronski (left) works with technician Chris Reuter (center) and entomologist Nelson Foster, both with APHIS, to use an APHIS-developed sprayer that simulates aerial fungus application to a small area of ground.

Like grasshoppers, Mormon crickets can wipe out acres of grasses and field crops through their voracious feeding. But these insects are also a danger to drivers. Cricket populations can build up so much that crushed insect bodies on highways can create road slicks, resulting in hazardous driving conditions.

Ecologist Bob Srygley is examining the cricket's immune system to better understand how the insect is defending itself from attack. His goal is to identify the best opportunity in a cricket's life cycle to use biocontrol methods that will reduce cricket populations.

But accomplishing his goal won't be easy. You see, Srygley wants to rear Mormon crickets in the laboratory so he doesn't have to wait to conduct tests on field populations. The problem: Rearing second-generation Mormon crickets in a laboratory hasn't been done before.

"Determining the rearing requirements for the cricket, like identifying critical temperatures for egg and nymph development, will help us better understand its reproductive process," says Srygley.

In the meantime, Srygley is conducting tests on crickets caught in the field. He has recently examined the role the cricket's diet plays in its immune system and how the immune system changes with development.

"We've found that young crickets want to grow quickly, so they sacrifice the growth of their immune system to allocate more resources for physical growth," says Srygley. "Based on enzyme assays of the last few nymphal instars and adults, we've also found that the immune system is weakened with each molt. When the insect reaches the adult stage, it simply adds mass without molting further and no longer needs to compromise its immune system. So it seems ideal to apply biocontrol agents during the insect's immature or early-adult life stages."

Srygley also conducted field experiments comparing protein-fed crickets with carbohydrate-fed crickets. He found bands of crickets in Utah whose diets lacked enough protein. As a result, the insects were deficient in an enzyme key to combating fungi. Similarly, Srygley found bands of crickets in Nevada whose diets lacked enough carbohydrates, which led them to be deficient in an enzyme involved in combating bacteria.

Srygley plans to further study this phenomenon by creating carbohydrate- and protein-deficient cricket populations in his laboratory. He hopes to be able to use this knowledge about the cricket's nutrient and enzyme deficiencies to help identify biocontrol agents to battle the pest.

Fungal Foes May Be Our Heroes

So what happens when an outbreak occurs? Currently, the main recourse is to use chemical sprays. But entomologist Stefan Jaronski and colleagues are examining other options, such as fungal biocontrol agents.

Jaronski is working with colleagues at the USDA Animal and Plant Health Inspection Service (APHIS), Utah State University, and the University of Wyoming to evaluate several domestic fungi. The fungi were found through an exploratory program led by Utah State professor Don Roberts. They have identified two candidate fungi that could be used to control grasshopper and Mormon cricket populations.

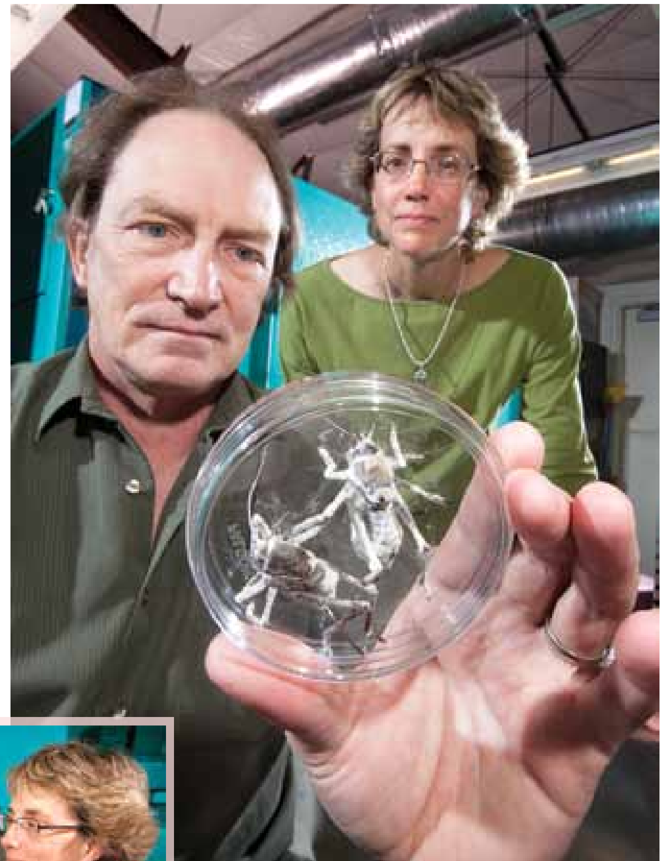
Field tests of the fungi, *Metarhizium robertsii* DWR 346 and DWR 356, began last summer in Montana, Wyoming, and Utah. The scientists are comparing the fungi with a commercial isolate that is registered by the U.S. Environmental Protection Agency to control tick and beetle populations. After a few years of testing, the researchers will be able to determine whether the fungi can be deemed suitable biocontrol agents.

Jaronski and his APHIS colleagues, led by entomologist Nelson Foster in Phoenix, Arizona, are working to receive permission to conduct field tests on a fungus called "Green Muscle." The product was developed by CABI, an international not-for-profit organization aimed at solving agricultural and environmental problems, and commercialized in Africa for locust control. A related strain has been commercialized in Australia as "Green Guard" for control of locusts and wingless grasshoppers.

"Green Muscle is *Metarhizium acridum,*" says Jaronski. "It's related to the domestic fungi we're currently testing but is specific to Orthoptera. With Green Muscle, we won't have to worry about it infecting other insects as we do with many of the domestic fungus candidates."

And that's just the beginning of Green Muscle's advantages.

STEPHEN AUSMUS (D2044-2)



Ecologist Robert Srygley (left) and technician Laura Senior inspect a male and female Mormon cricket exposed to the insect-killing fungus *Beauveria bassiana*.

STEPHEN AUSMUS (D2045-3)

Using a dissecting microscope, Laura Senior and Robert Srygley screen Mormon cricket eggs for fertility. The egg in the middle has a prominent eye spot that shows the egg is developing; the other two are infertile.

Normally, when the grasshoppers' and crickets' immune systems detect invasion by a fungus, they deploy blood cells and generate melanin to encapsulate it and keep it from growing. Green Muscle can evade recognition and, if detected and encapsulated, can grow and burst through the insect's defenses.

Grasshoppers and crickets also use "behavioral fever" to prevent a fungus from growing inside them. Most fungi stop growing at 32-34°C, while the insects—especially diseased ones—can heat their bodies up to 38-40°C by extra basking in the sun. The heat exposure stops the fungus from growing, helping to keep the insects alive. But *M. acridum* fungi like Green Muscle have better temperature tolerance and don't experience heat shock. As a result, grasshoppers and crickets succumb to infection after 5-10 days.

It takes just a few hundred spores of Green Muscle to successfully infect a grasshopper. Other fungi require several thousands of spores per insect to ensure infection. This feature means Green Muscle should allow users to reduce their current pest control costs significantly.

"We're really trying to cover all our bases here," says Jaronski. "When prevention fails, we need to use targeted, suppressive, environmentally safe tools to effectively manage an outbreak."—By **Stephanie Yao,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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